

Status of the luminosity monitor

20 Oct, 2004

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John Byrd



People

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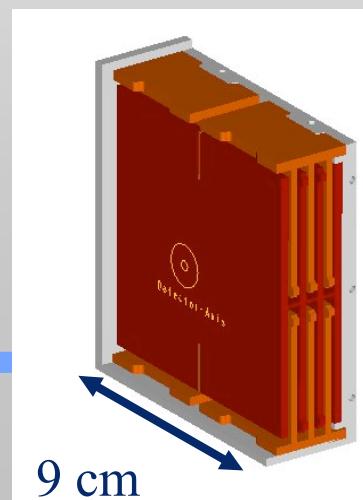
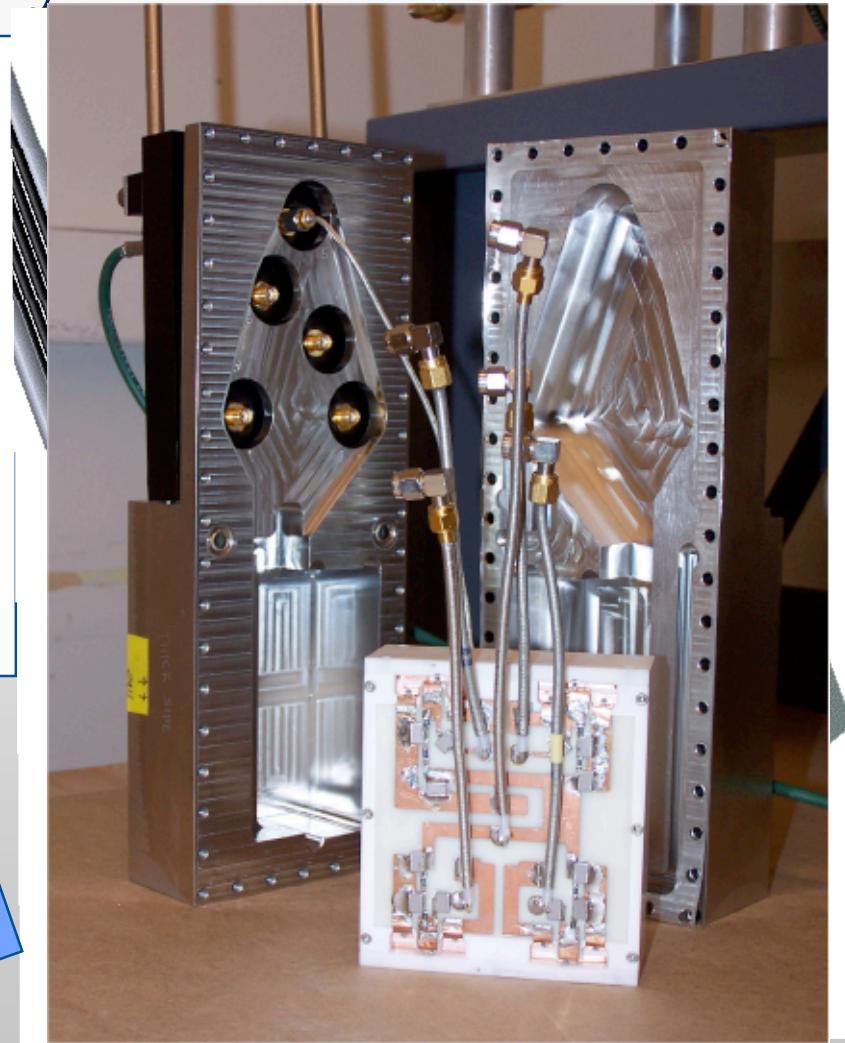
LHC Luminosity Monitor

The challenge:

- High radiation environment (100 MGy/year)
- Bunch-by-bunch capability (25 nsec separation) with 1% resolution.

The solution:

- Segmented, multi-gap, pressurized ArN_2 gas ionization chamber constructed of rad hard materials

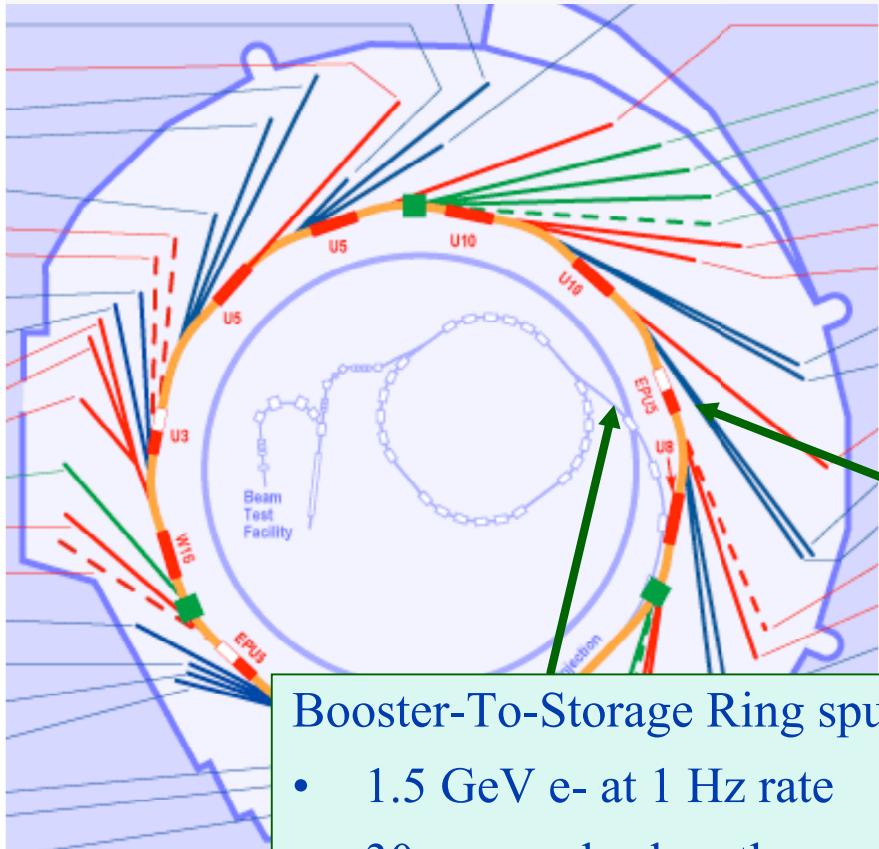


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Luminometer Beam Tests



- Booster-To-Storage Ring spur:
- 1.5 GeV e- at 1 Hz rate
 - 30 psec pulse length
 - intensity from 1 to $1e9$ e- (1e3 typical)
 - daily access and availability

Use beam test facilities at the ALS to provide MIPs for the detector to test

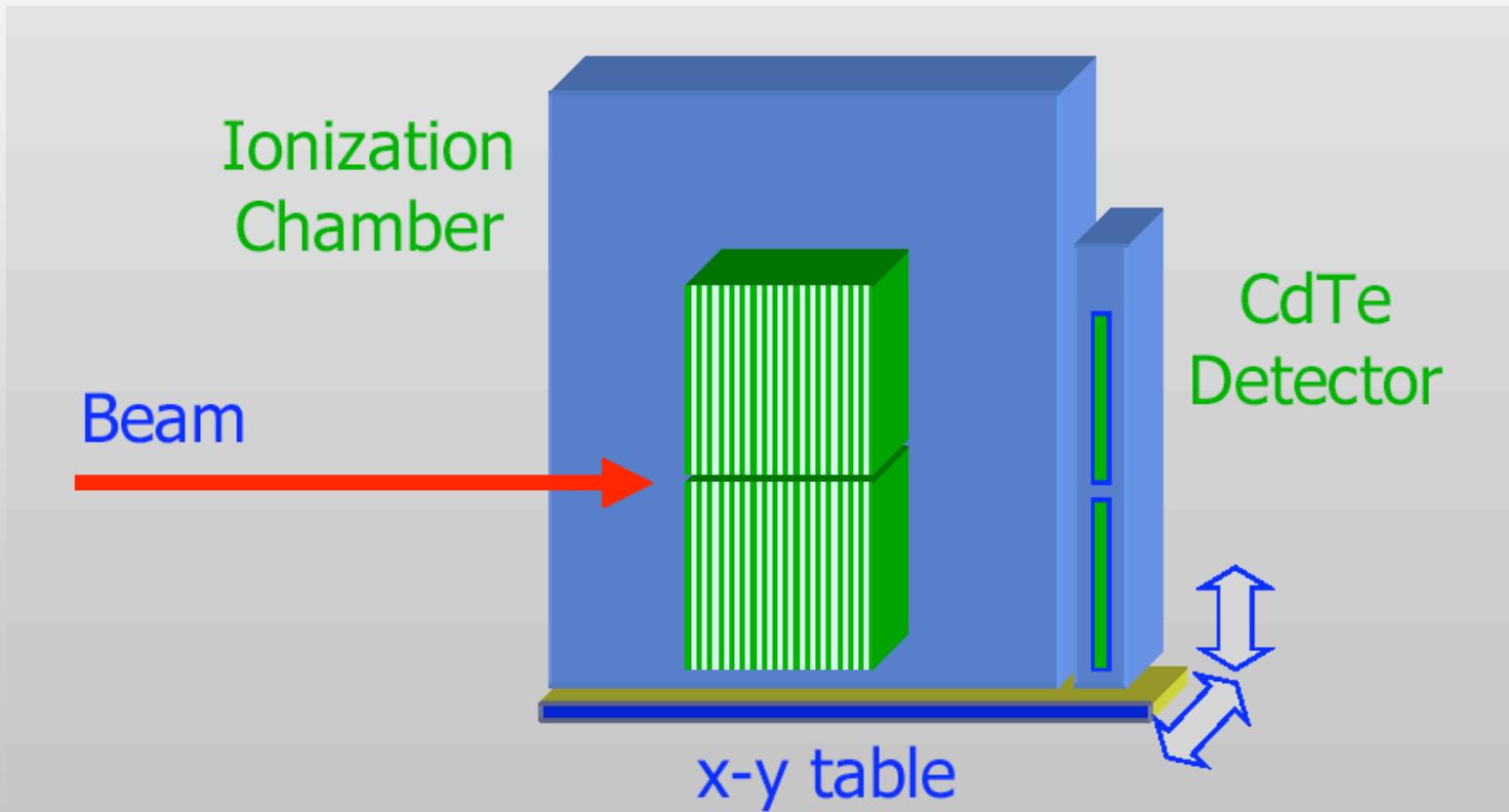
- position sensitivity
- time response and gain
- accuracy
- operating experience over long time periods

- Storage Ring spill:
- 1.5 GeV e- with variable spacing
 - 30 psec pulse length
 - intensity of a few e-
 - weekly access



BTS Tests

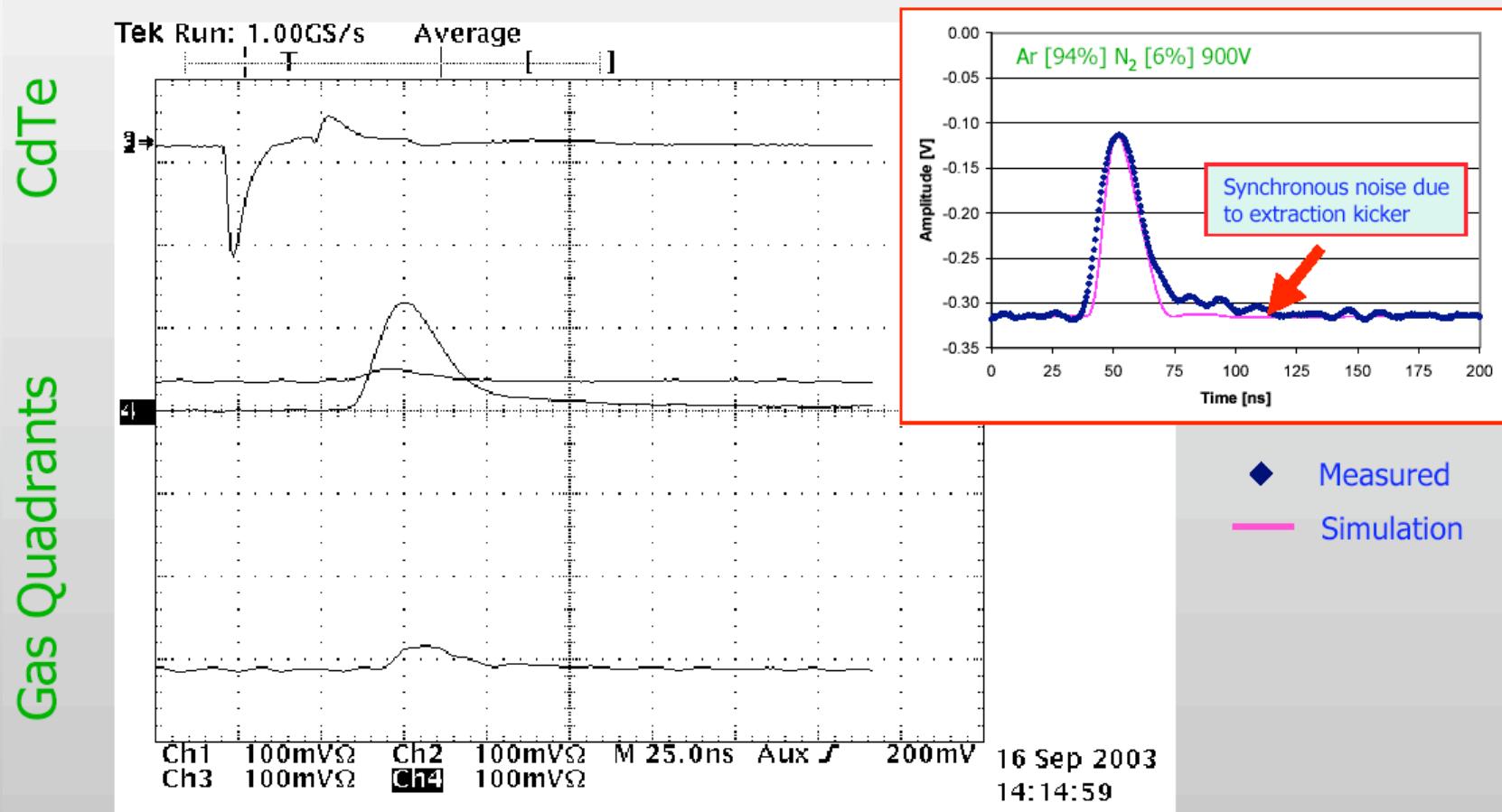
- “delta-function” e- beam (50 ps); 1.5 GeV; 1 Hz
- Adjustable intensity (typically ran at 20 pp \pm 50%)



BTS Setup



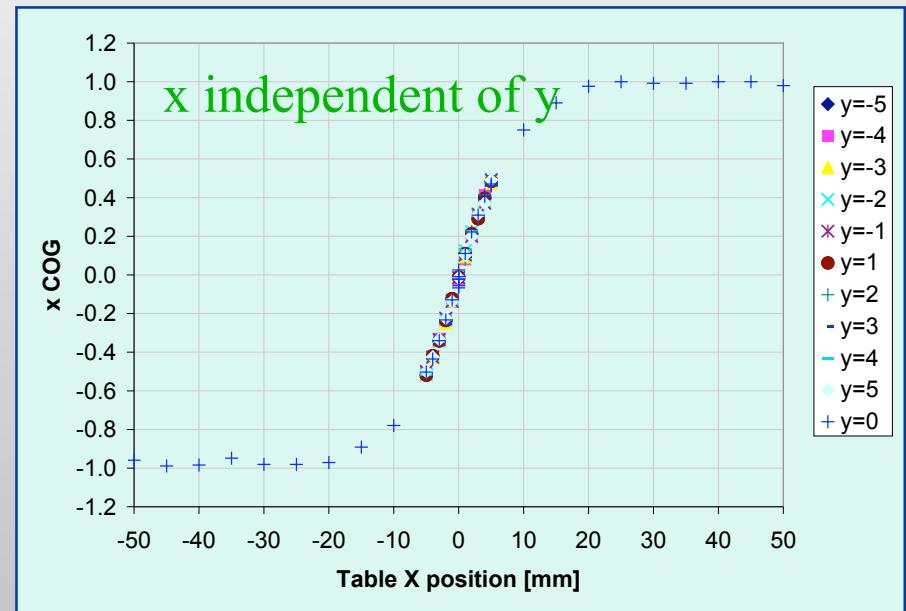
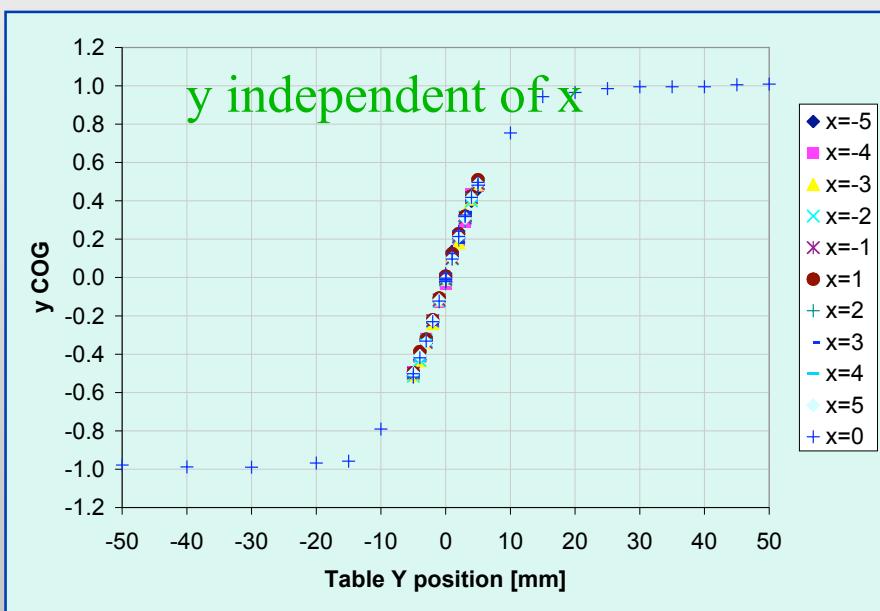
BTS Waveforms



Position Sensitivity

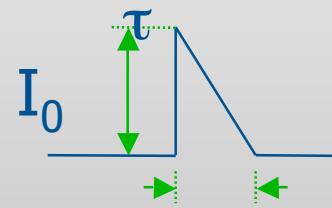
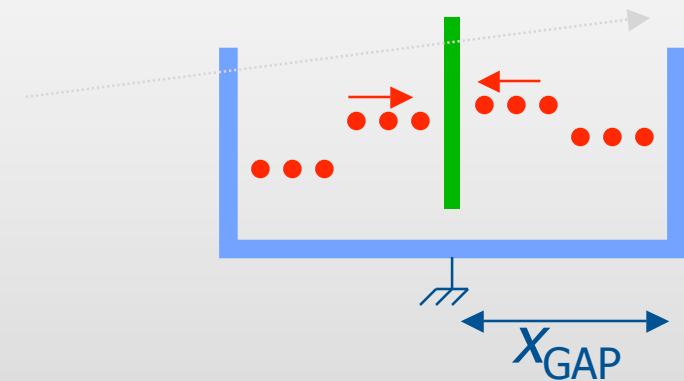
- Raster scan detector through pencil beam
- Record 4 quadrants:
 $x = (\text{left-right})/\text{sum}$
 $y = (\text{top-bottom})/\text{sum}$

- Ionization chamber works as a true 4-quadrant detector
- x and y are independent (no crosstalk)
- Position resolution < 110 μm



Gas Tests

- Chamber uses Ar (100-x %) + N₂ (x%)
- Design was based on Monte Carlo calculations of gas properties
- Drift velocity is key parameter (determines speed)



$$\begin{aligned}\tau &= x_{GAP}/v_D \quad Q = \int_0^\tau I(t)dt = \frac{1}{2}I_0\tau \\ &= 9.7 \text{ e}^-/\text{MIP/mm} \times 231 \text{ MIP/h} \times x_{GAP} \times P \times N_{GAP}\end{aligned}$$

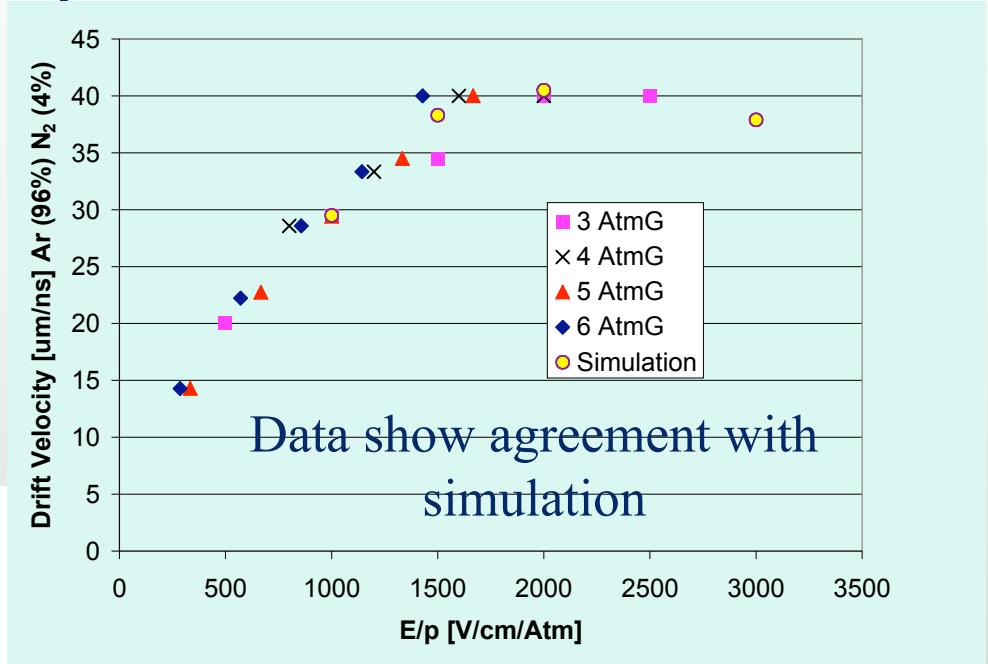
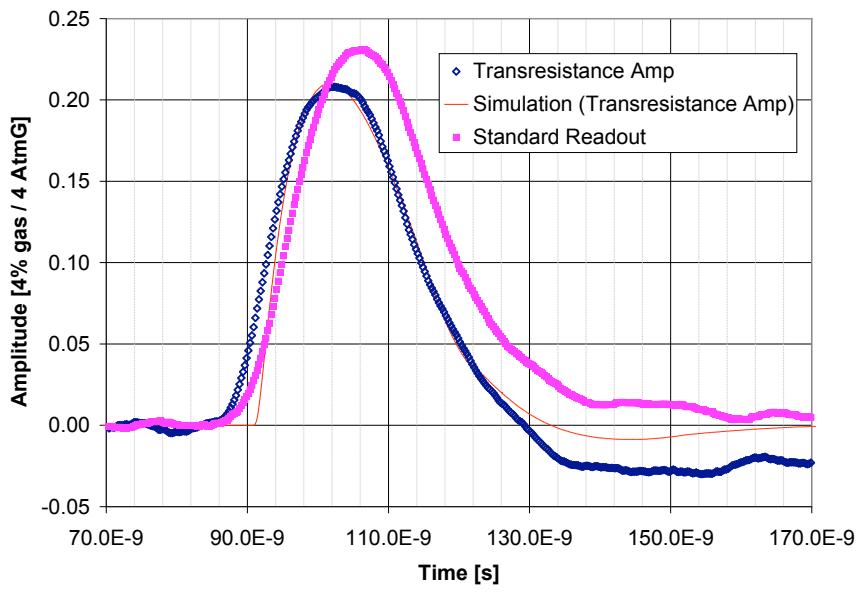
$$I_0 = 2 Q_0 v_D P N_{GAP}$$

$$= 0.72 \text{ nA} \times v_D [\mu\text{m/ns}] \times P [\text{Atm}] \times N_{GAP}$$



Detector response time

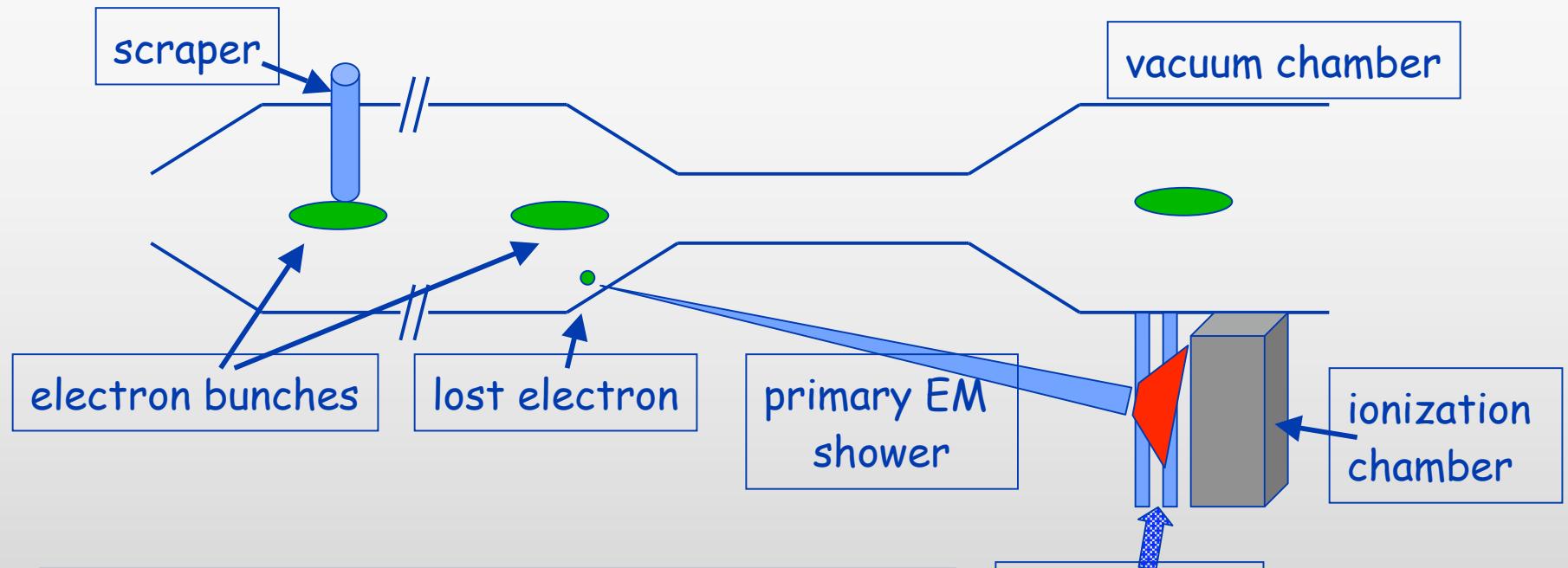
Measure pulse response for varying pressure, gas mixture, and voltage. Derive drift velocity from fit using electronics response.



Pulses a bit longer than expected due to additional capacitance of detector/cable but still suitable for 25 nsec operation.



Simulate LHC Pulse Rate in the ALS

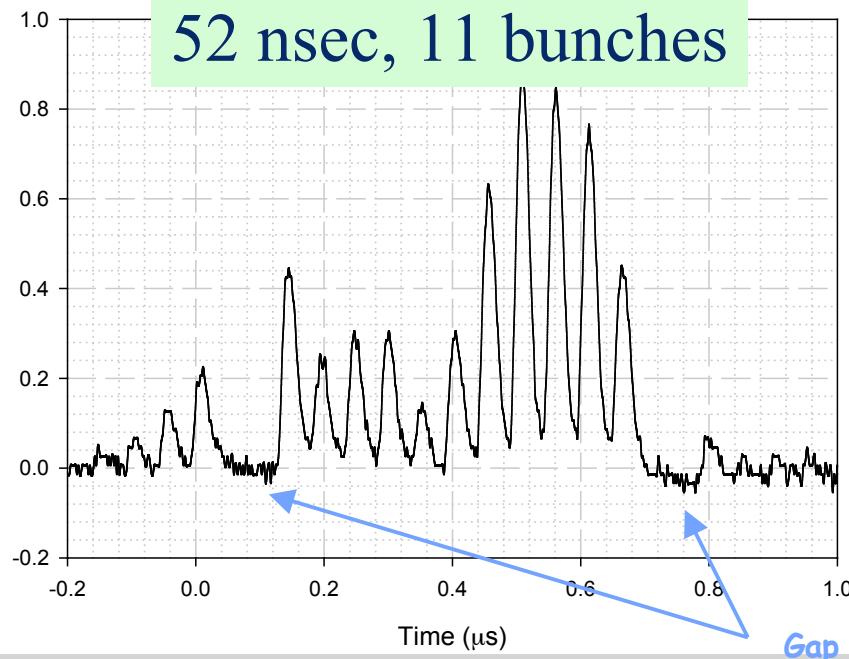


Fill pattern adjustable with 2 nsec
spacing into 328 buckets. Test up to 24
nsec spacing.



Fast Pulse Beam Test Results

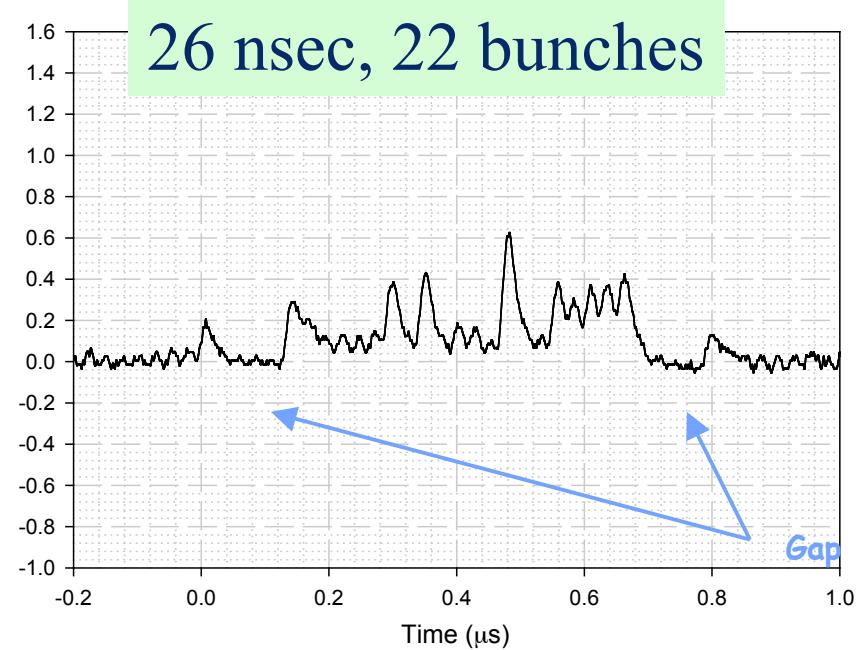
Quadrant 3 - 4% Mixture - 2.5 atm - HV = 500V
38 MHz Pattern



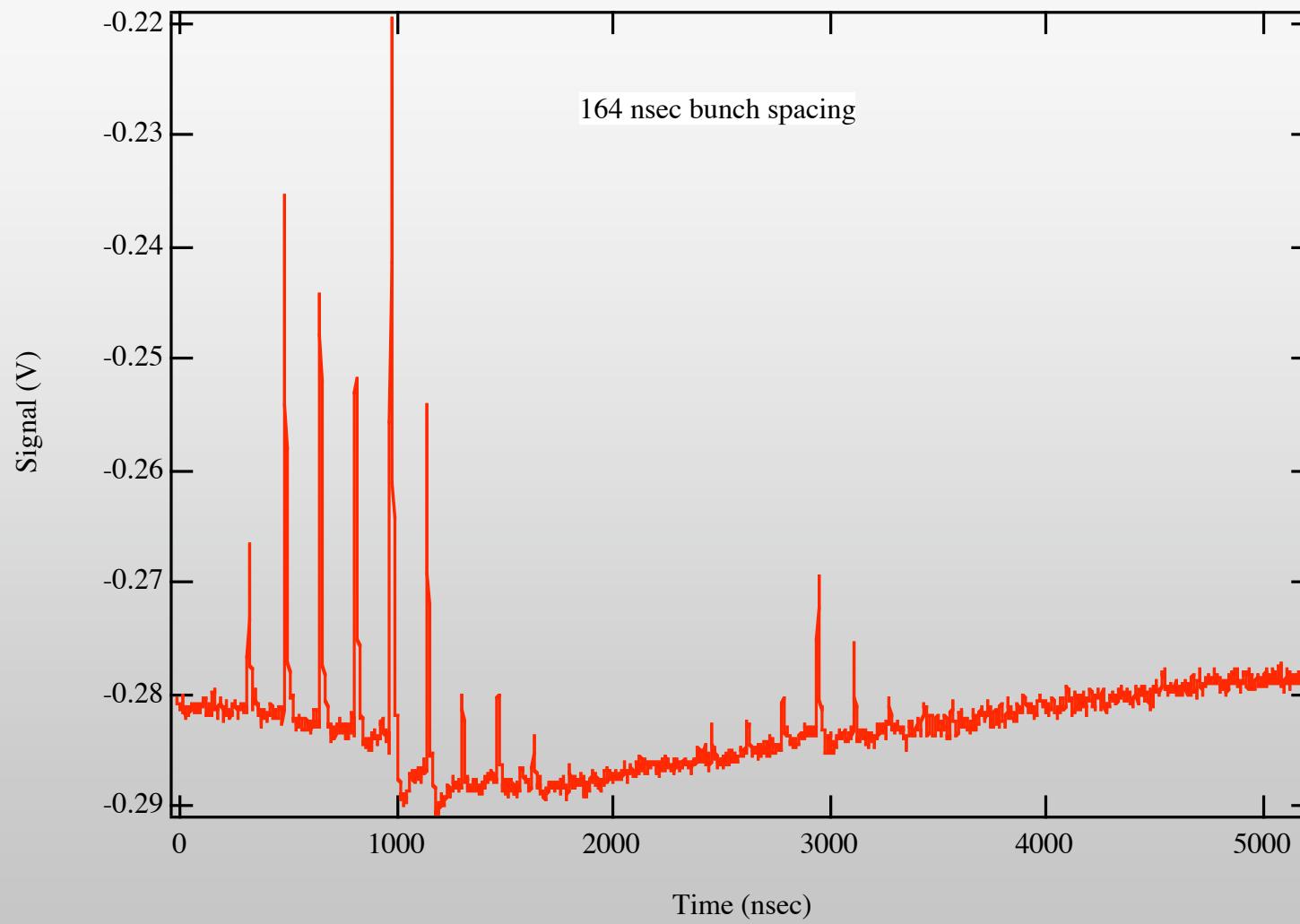
Further studies to determine if pulses can be deconvolved to 1% accuracy.

Spilled ALS beam provides a test of LHC conditions.

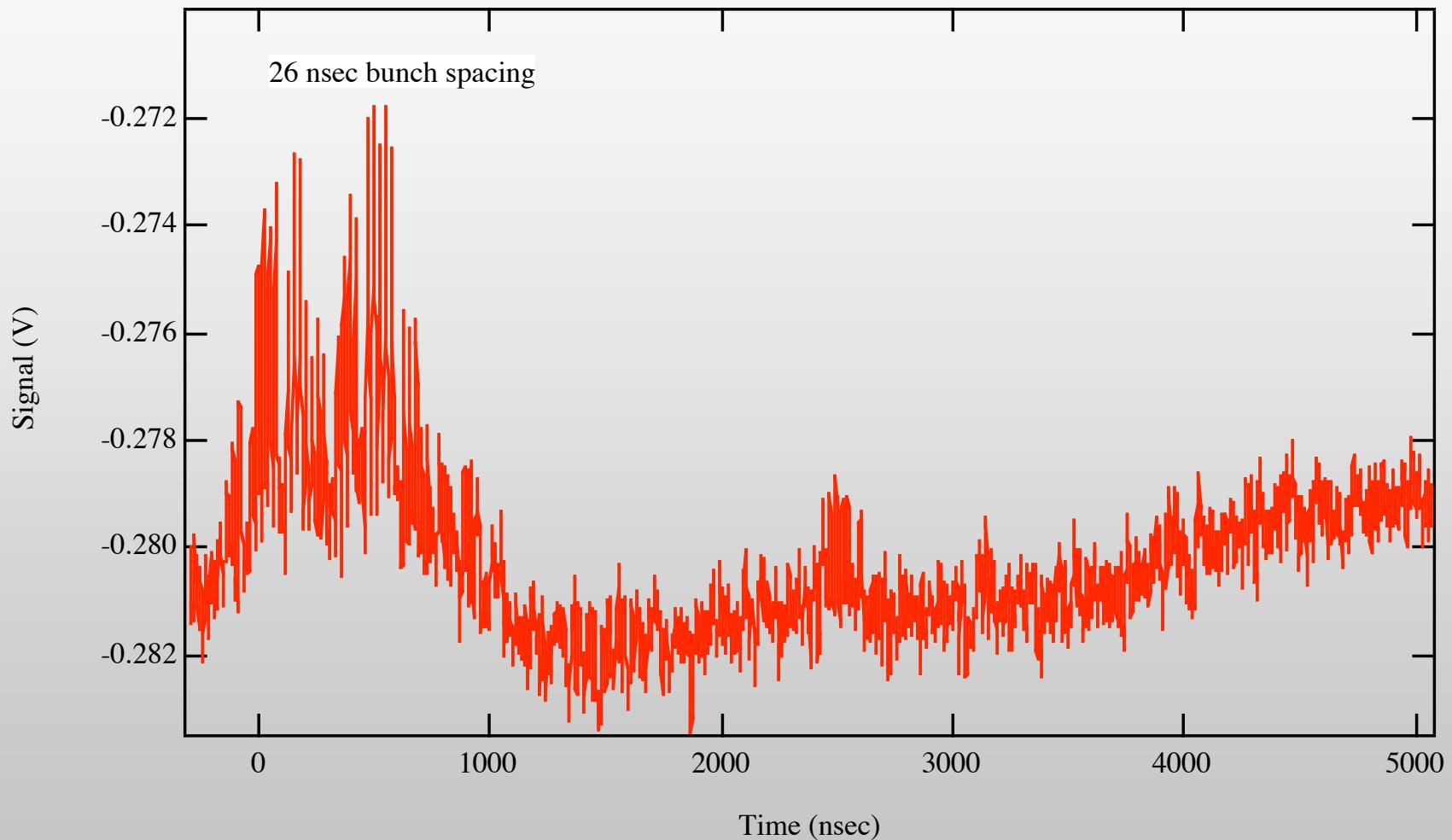
Quadrant 3 - 4% Mixture - 2.5 atm - HV = 500V
38 MHz Pattern



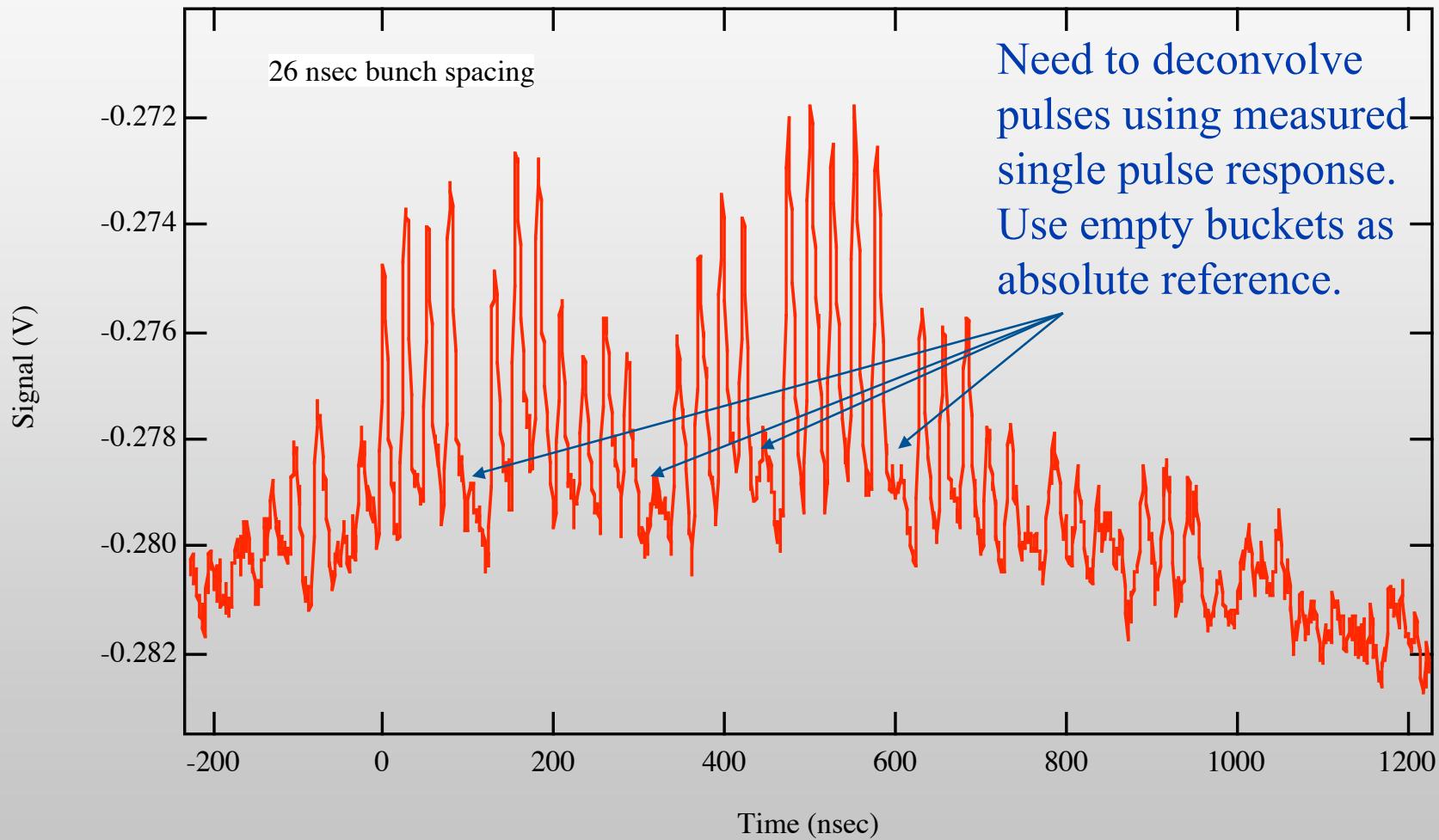
Results from 12 June 2004



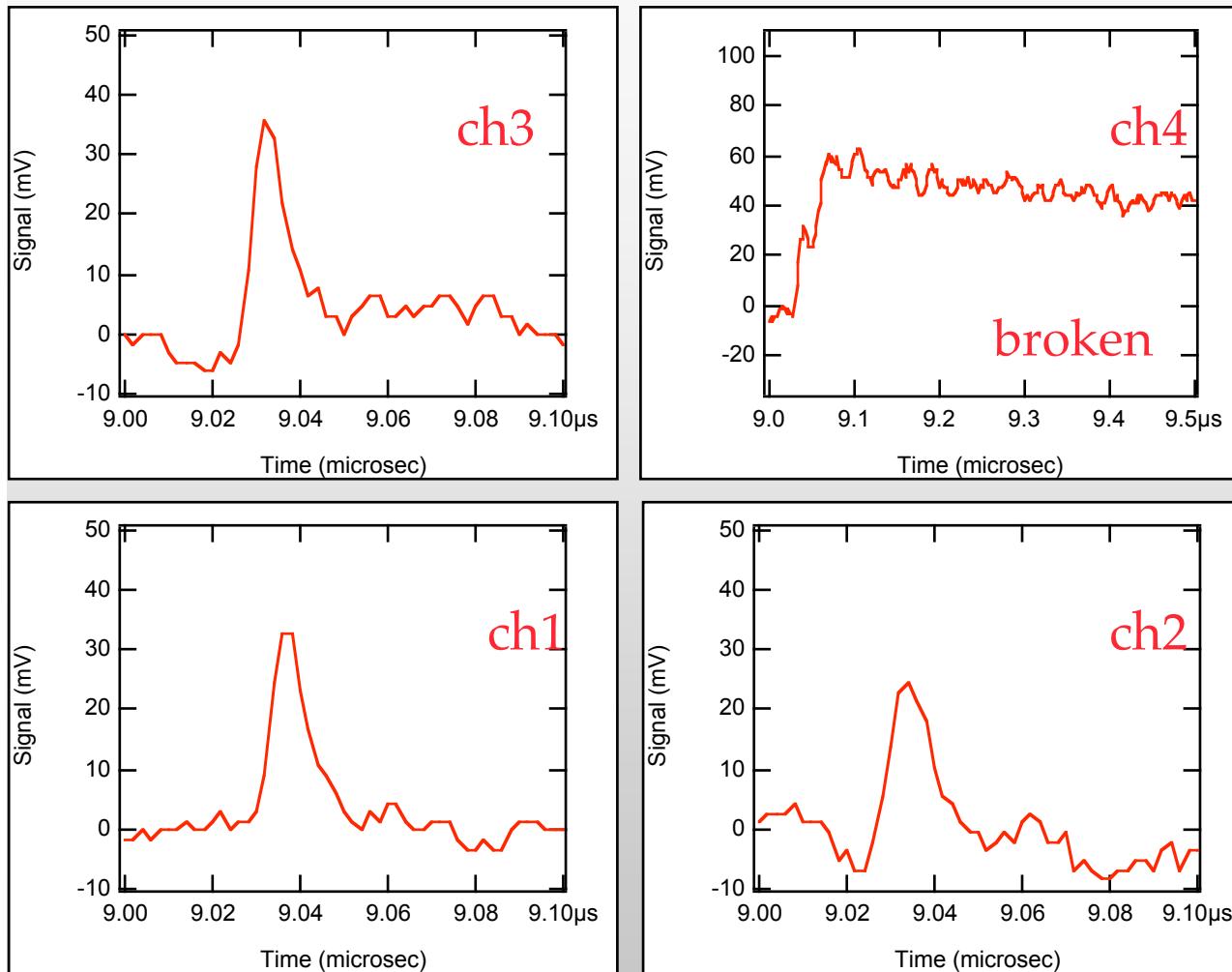
Recent results 26 nsec spacing



26 nsec bunches zoom



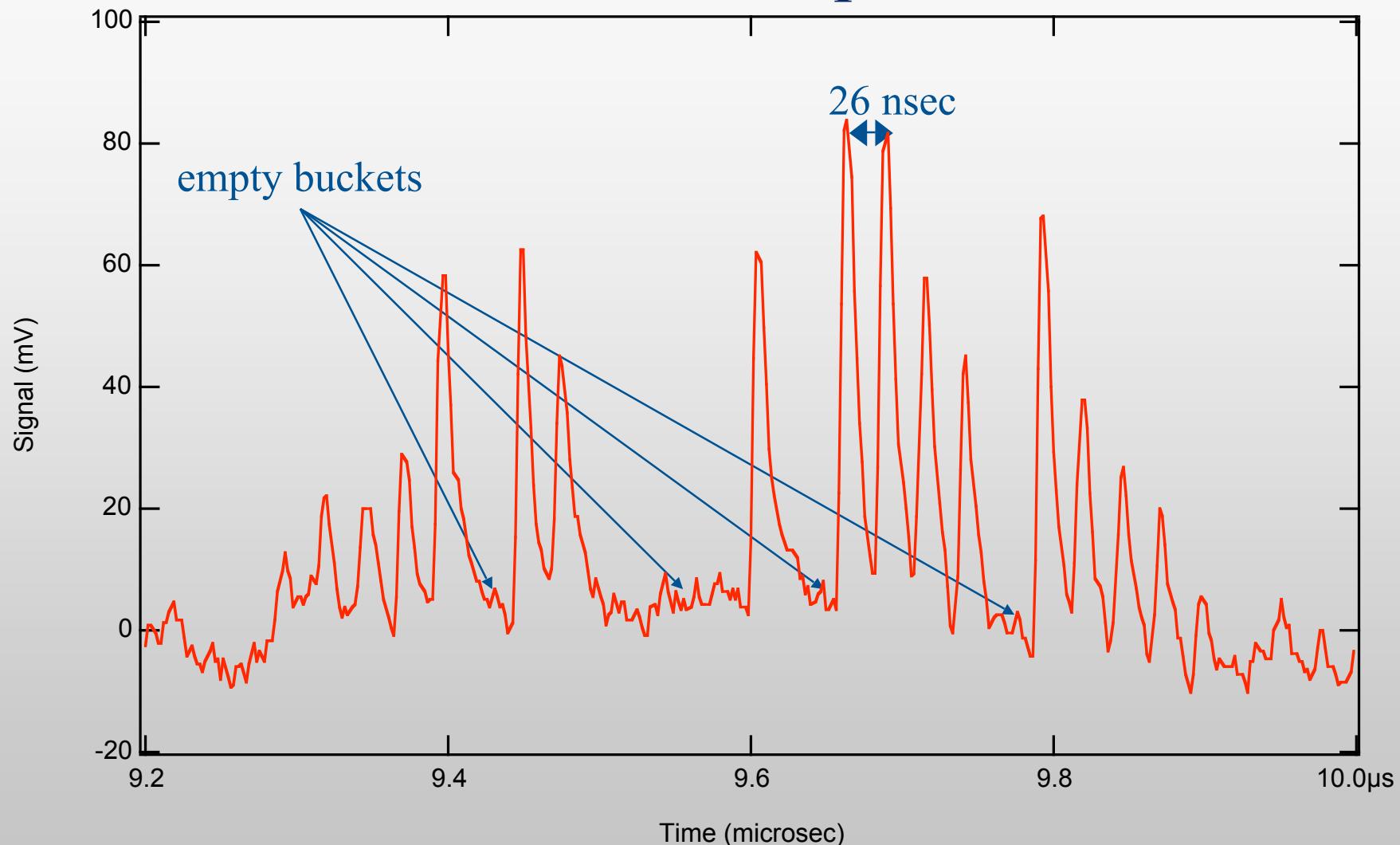
Single pulse response



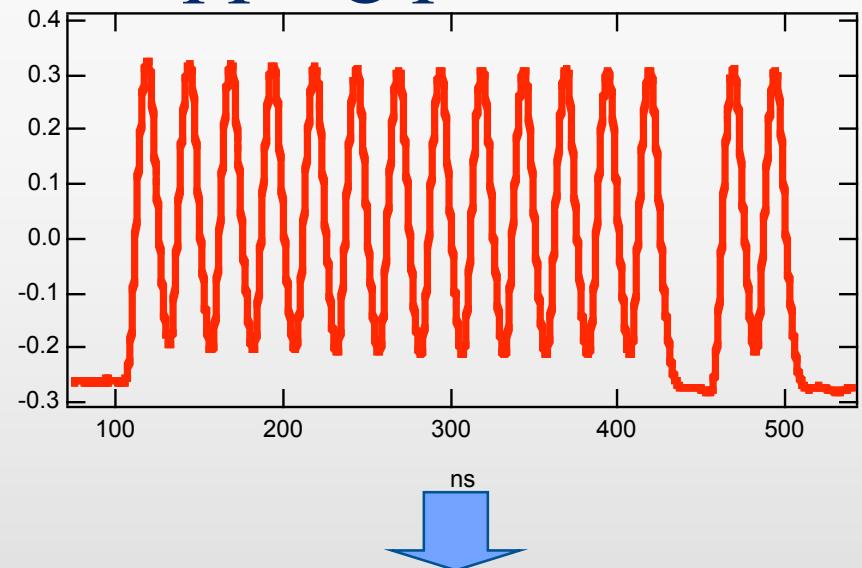
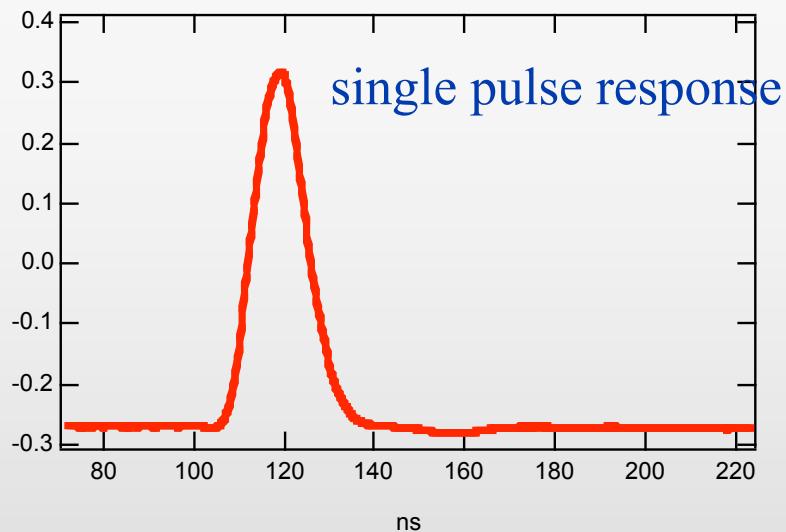
- data from 6 July 2004
- single bunch pattern in the ring
- 3 channels show base width \sim 25-30 nsec
- SNR unable to resolve long tails...pulse train needed to see effect
- good agreement with bench tests of electronics



Pulse train response

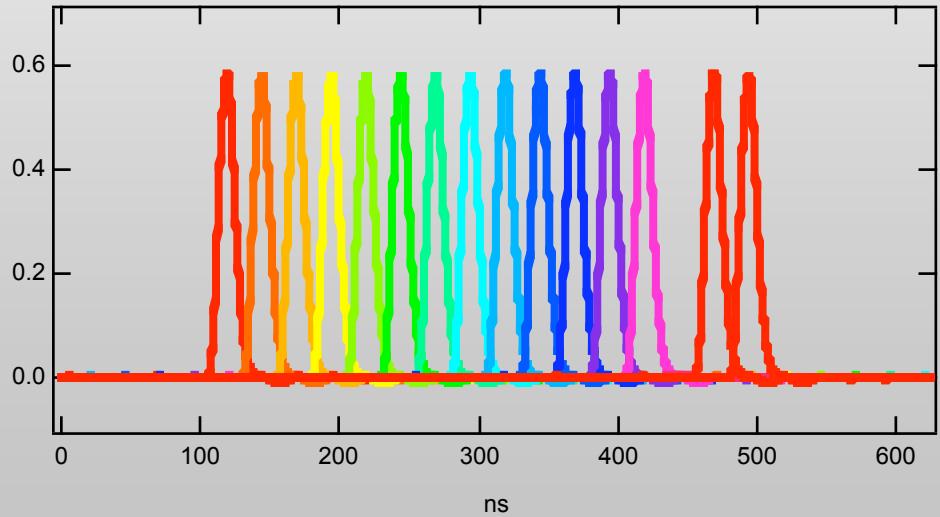


Deconvolution of overlapping pulses

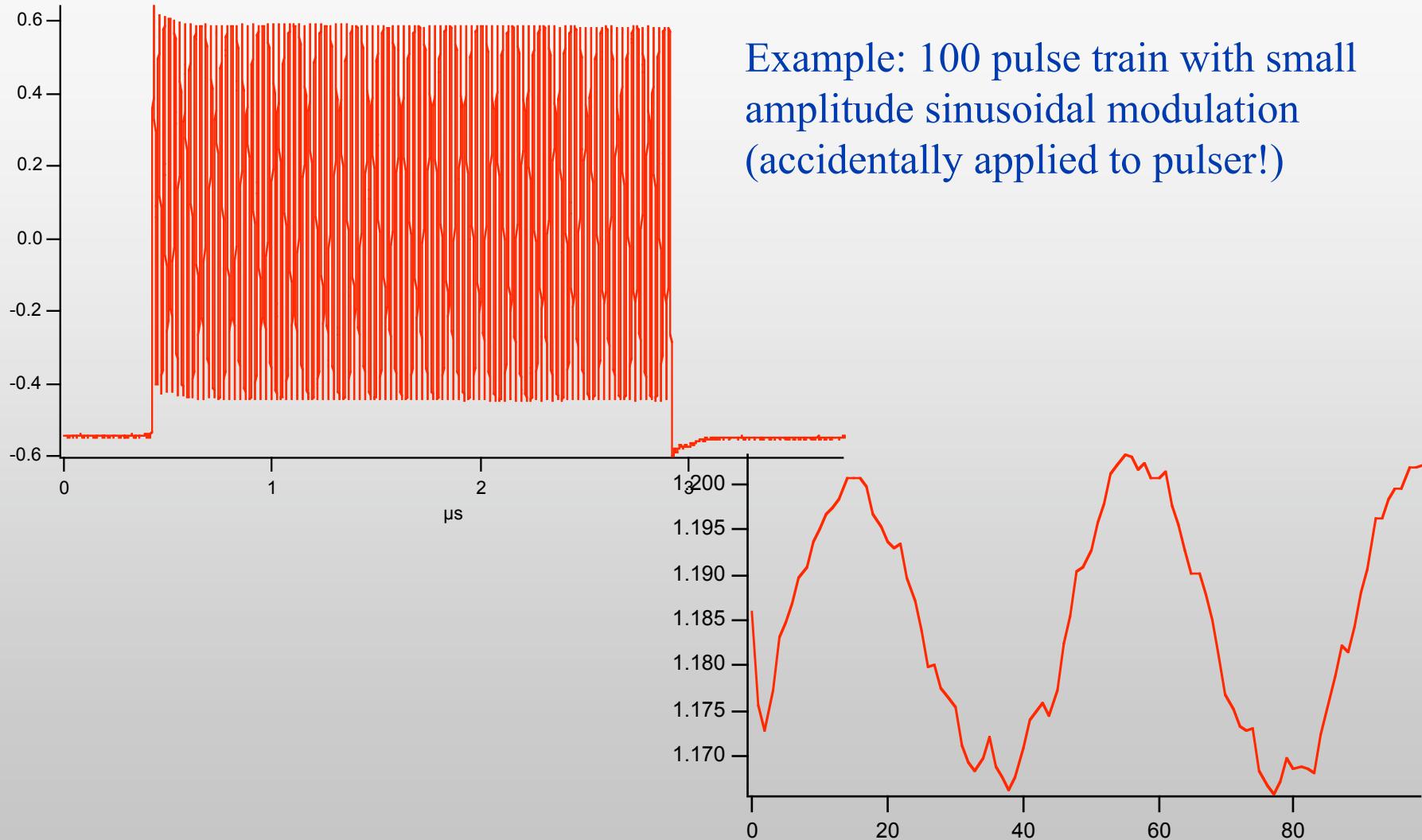


Test deconvolution process using electronics driven by pulser

Further work in progress:
-peak accuracy vs. SNR
-effect on channel nonlinearity

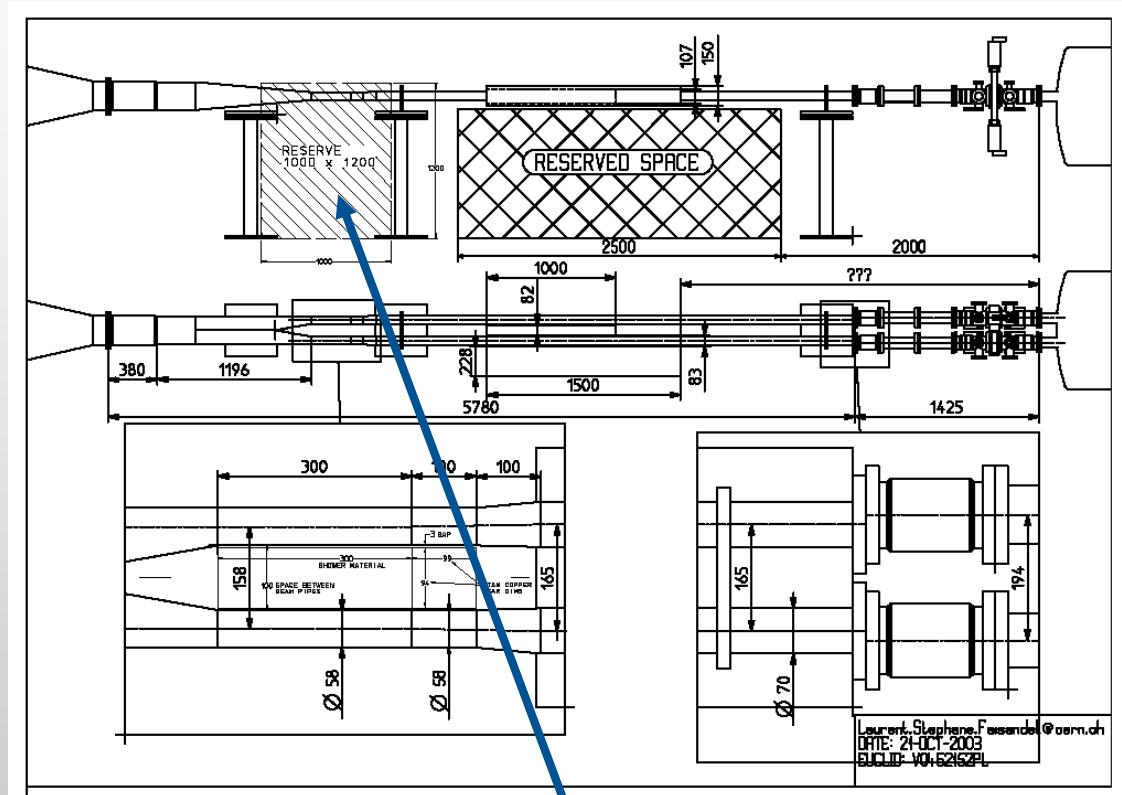


Deconvolution



Possible installation in IP2 and 8

- Effort to define envelope for installation at “low” luminosity IPs for use in p-p operations
- No TANs-IC detectors require supports and must be moved for Pb-Pb operations.



sufficient space for IC Lumi



FY04 Results

- FY04 budget \$162k
- Detailed study of lumi test in FNAL booster radiation test facility; eventually aborted
- Engineered, designed and built first TAN-compatible prototype chamber
- Development of beam test facility at ALS
 - booster test stand for precision tests at 1 Hz
 - storage ring test stand for 38.5 MHz tests
- ready to begin engineering of production prototype
 - improved mechanical design
 - fixed arcing problems
 - optimised front-end electronics
- preliminary work for installation in IP2+8



Plans for FY05

- FY05 budget expected to be \$395k
- Mechanical
 - Design and build final prototype
 - HV distribution redesign (current setup uses PCB)
 - Radiation hardness of HV distribution components (resistors and caps)
 - radiation hardness of chamber materials
- Electrical
 - Finalize preamp and shaping design
 - Integrate electronics into a package which meets CERN requirements
 - Demonstrate operation with CERN 40 MHz DAQ
- Beam tests
 - repeat detailed measurements of chamber response vs. voltage, pressure, etc. (with new ATLAS graduate student)
 - develop test for amplitude calibration of detector
 - integrate CERN DAQ into beam tests at ALS
 - investigate precision 40 MHz beam source

